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Research Article/Araştırma Makalesi

The Effect of Braking Pressure on Friction and Wear Properties of Brake Lining

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Abstract
The brake system is used to slow down or stop the vehicle speed. The brake lining is the most important part of the brake system, which is used to slow down or stop the vehicle by converting friction energy into heat energy. The pressure applied to the linings in the vehicle brake system is an important factor for the lining performance. The brake lining exhibits different properties depending on the pressure applied during braking and the brake lining content. In this study, friction coefficient and wear properties of brake linings at braking pressures of 5, 10 and 15 bar were investigated. The pressure increase increased the disc surface temperature and the wear amount of brake lining.

1. Introduction

Vehicle braking systems are used to slow down and stop vehicles. vehicle braking system; It consists of brake lining, caliper, disc, brake fluid and fasteners. In the brake system, the brake linings rub against the disc surface and stop the vehicle. The most important factor in slowing down the vehicle is the pressure applied to the brake pedal. The parameters that affect the braking performance reveal the functional state of the brake system. These parameters can be evaluated as brake system components, wheel and road conditions. The effects of the specified parameters on the braking force can be determined experimentally or mathematically (Bayrakçeken and Altıparmak 2007:22).

The force on the brake pedal while the vehicle is in motion; Due to the high pressure in the brake system line, the brake force values on the wheels are also high. By keeping the pressure in the brake fluid line constant, the brake force remains approximately constant (Bayrakçeken et al., 2020:20).

The pressure applied to the brake pedal affects the wear process of the brake lining. The pressure applied to the brake pedal affects the wear process of the

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brake lining. During continuous braking, the amount of brake lining wear increases (Chen et al., 2019:426-427).

Numerous studies have been conducted on braking system efficiency and performance. While some of these studies were on the brake system and its components, some were on the brake pedal force and stopping distance of the vehicles (Sun et al., 2015:).

It was observed that the brake inner line pressure increased as the force applied to the brake pedal increased. Accordingly, the force applied by the caliper to the brake linings has increased and the full braking distance has decreased (Bayrakçeken et al., 2020:20).

In this study, the change in brake lining performance at 5, 10 and 15 bar braking pressure was investigated. The samples used in the experiments were coded as P5 for 5 bar, P10 for 10 bar and P15 for 15 bar.

2. Materials and Method

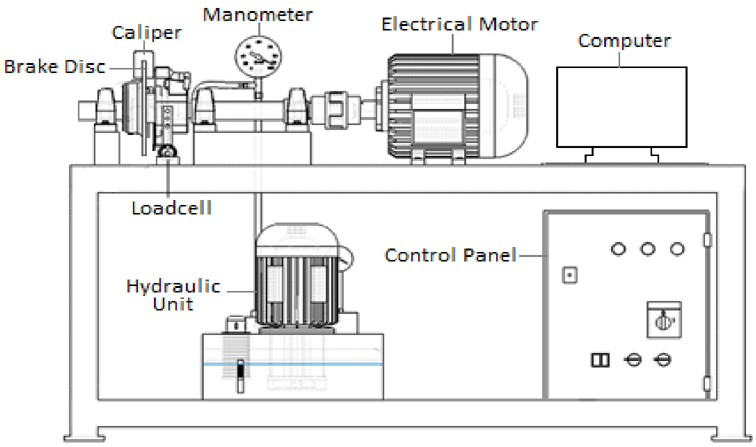
There are many parameters that affect the friction performance of brake linings. One of these parameters is the braking pressure. In this study, 3 brake linings with the same content were produced. The produced brake linings were tested at different braking pressures such as 5, 10 and 15 bar. The samples used in the experiments were coded as P5 for 5 bar, P10 for 10 bar and P15 for 15 bar. Mass ratios of materials used in brake lining content are given in Table 1.

Table 1. Material ratios in the mixture (% by mass)

Ingredient	W
Phenolic resin	20
Copper particles	10
Alumina	8
Graphite	5
Brass particles	10
Cashew dust	10
Barite	37

In the powder materials, the ratios of which are given in Table 1, were weighed with a sensitivity of 0.001g and transferred into the powder mixer to be mixed. The homogeneous mixture obtained by mixing in the powder mixing device at a speed of 300 rpm was transferred to a mold with a diameter of 25.4 mm and a pressure of 100 bar was applied for 2 minutes at room temperature as a pre-treatment. It was then hot pressed for 10 minutes at 180ºC by applying a pressure of 150 bar. Properties of sample brake linings such as wear and friction coefficient; It was obtained with a brake lining tester (Figure 1) operating at desired criteria such as 1-30 bar pressure, 50-600ºC temperature, 100-1400 rpm.

Figure 1. Brake lining test device



In order to ensure that the friction surfaces overlap, the device was operated at a speed of 3 m/s under 2.5 bar pressure until 95% of the sample surface came into contact with the disc surface. The experiments were carried out at 5, 10 and 15 bar brake lining surface pressure and 6 m/s speed. The friction coefficient and time values taken during the experiments are the arithmetic average of the values taken from the three samples produced with the same mixture and properties.

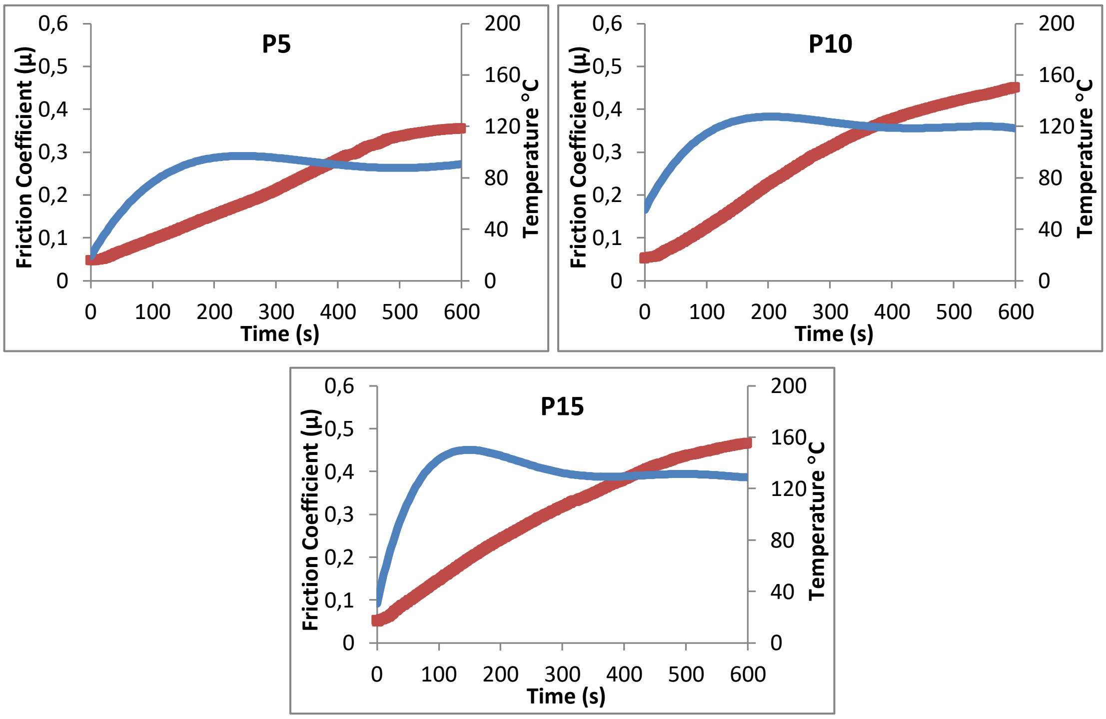
The friction coefficient for each sample was recorded at 1 second intervals at a speed of 6 m/s at a pressure of 5, 10 and 15 bar. In the wear tests, the brake lining samples were calculated by constructing a 3600 m (3.6 km) road.

The hardness measurements of the samples were determined with a Rockwell (HRL) hardness measuring device (Sugözü, 2018:70). The mass loss of each brake lining sample was found by weighing it on a precision balance. The mass loss found was calculated with the formula based on the mass loss given in TSE 9076, and the specific wear values were determined (TSE 9076, 1991). Density measurements of the samples were determined using Archimedes' principle in water (Sugözü, 2018:70).

3. Results and Discussion

In this study, brake linings with the same content were tested at 5, 10 and 15 bar braking pressure, and the effect on braking performance was investigated. Figure 2 shows the friction coefficient and temperature change of the brake lining at 5, 10 and 15 bar braking pressure.

Figure 2. Friction coefficient-temperature change of brake lining samples



When the figures are examined, it is seen that the friction coefficient increases as the braking pressure increases. In the P5 coded brake lining tests, the maximum temperature was 120 °C and the average friction coefficient was 0.25.

In the P10 coded brake lining tests, the maximum temperature is 150 °C and the average friction coefficient is 0.33. In the P15 coded brake lining tests, the maximum temperature is 160 °C and the average friction coefficient is 0.39. When Figure 2-4 is examined, the friction layer development of the brake lining samples continued until the 150th second of the test period, and after this minute, the friction performance was shaped according to the braking pressure. One of the most important features required from brake linings is to exhibit a stable friction performance during braking (Chen et al., 2019:426-427). As the brake pressure increased, the friction of the brake lining on the disc surface increased, which caused an increase in the disc surface temperature. When the studies in the literature are examined, it is stated that the increase in disc surface temperature affects the friction coefficient negatively (Fan et al., 2010:70, Deng et al., 2010:270).

The tribological and physical properties of the sample brake linings are given in Table 2. The hardness value of the brake linings with the same content was determined as 96 HRL and the density was determined as 2.01 g/cm3.

Table 2. Experimental data of brake lining samples

Sample	Hardness (HRL)	Density (g/cm^3)	Average friction coefficient (μort)	Specific wear rate (cm^3/Nm)
P5	96	2,01	0,25	$1,3x10^{-6}$
P10			0,33	$1,6x10^{-6}$
P15			0,39	$2,2x10^{-6}$

Friction When the table is examined, it is seen that the specific wear rate of the brake linings increases as the braking pressure increases. As the pressure increases, the pressing force between the disc and the brake lining contact surface increases. As the pressure increases, the pressing force of the brake lining on the disc surface increases. This situation causes more friction of the brake lining to the disc surface and causes more wear of the brake lining. It is stated that the brake lining wear rate may vary depending on the production parameters, brake lining content, physical properties of brake lining and applied brake pressure (Sugözü, 2015:57, Sugözü, 2018:70, Matejka et al., 2010:43).

4. Conclusions

In this study, the effect of brake pressure on brake lining performance was investigated. In this context, the brake lining performance was examined with the tests performed at 5, 10 and 15 bar braking pressures and the following results were obtained;

- As the braking pressure increased, the friction force increased.
- Increased braking pressure increased the amount of wear. The amount of increase is among the standard values.
- The increase in the friction coefficient decreased the vehicle braking distance.
- The increase in friction force increased the friction coefficient.
- Disc surface temperature increased due to the increase in brake pressure.

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